ARRANGEMENT FOR THE DIRECT CONTROL OF THE MOVEMENT OF A ZOOM SYSTEM IN A STEREO MICROSCOPE

Insrt A1 ~~1. Prior Art~~

Stereo microscopes with varifocal objectives (DE 4315630 C2) are increasingly used as observation instruments for manipulating and monitoring tasks in which the user holds the instrument in both hands. Motorization of the zoom and focus operation functions and, for example, operation via foot switches or ergonomically arranged operating controls appreciably facilitates operation for the user. The zoom and focus operating functions in modern operation microscopes, for instance, which are also stereo microscopes from the stand point of their optical principle, are basically motorized and control is carried out predominantly via a foot switch.

With regard to the set of problems described above relating to motor-operated moving optical elements, zoom or focusing systems and motorized driving elements, a large number of different suggested solutions are already known.

U.S. Patent 5,661,598 (NIKON), entitled "Optical Instrument", describes a fully motorized optical instrument (embodiment example: telescope type operation microscope) in which the zoom system, the focusing system (z-direction), and the instrument movements in the x- and y-direction at the stand are moved by individual motor drives. All drives are controlled by means of an ocular switch, as it is called, i.e., corresponding eye movements are converted into control signals for the drives via a sensing system arranged at the oculars and via control software.

The patent DE 3808510 (C1) entitled "Electrodynamic actuator for optical storage systems" describes the construction of an electrodynamic drive unit for the movement of optical units; a control principle for optical zoom systems is not the subject matter of the patent.

Patent EP 0744650 A2 961127 (KODAK), entitled "Self-calibrating actuator position monitoring system, in particular for camera shutters, iris controls, zoom objective actuation, and the like", describes an optical sensor whose control signal is used for self-calibration of optical-mechanical function units, for example, of cameras, which are movable by means of electric drive units.

Patent EP 0646769 A1 950405 (SONY), entitled "Displacement measurement apparatus having first and second servo control circuits and a zone decision circuit", describes an arrangement and a process for optical focus control in which, among other things, an objective lens is displaced by means of an electric linear drive.

Patent DE 4224824 (A1) (SAMSUNG), entitled "Objective lens drive device for an optical receiver", describes an arrangement for driving an objective lens and for the flexible bearing of the driving device.

U.S. Patent 5,258,798 (MINOLTA), entitled "Camera", describes a (single-channel) camera zoom system driven by a linear motor.

The following are representative examples of a large number of patent applications describing various basic principles of optical systems which are used for reading CDs or OCDs and are moved via linear drives: U.S. Patent 5,187,702 (TOSHIBA), entitled "Apparatus for moving an optical system", U.S. Patent 5,623,372 (NEC corporation), entitled "Thin type optical head", and U.S. Patent 5,563,853 (CANON), entitled "Magneto-optical recording apparatus that compensates for magnetic fields leaking from an objective lens actuator and a linear motor."

In patent DE 296 02 202 U1, entitled "Linear adjusting unit for autofocus systems", a master image is projected onto an image surface via a projection objective for an autofocus projection system in that, for the purpose of focusing the imaging, the objective is supported in an objective holder so as to be movable in the axial direction and the movement is regulated in the axial direction by electromechanical means by a driving unit (linear drive).

U.S. Patent 5,612,740, entitled "Inner focus type zoom lens driving mechanism", describes a zoom system outfitted with a linear drive for use in a CCD camera.

U.S. Patent 5,365,296 (CANON), entitled "Motor and an optical apparatus having such motor", describes the construction and the operation of special piezo-electric linear drives for driving zoom and autofocus systems, including combined control of all function parameters of an automatic CCD camera (camcorder).

The known solutions for a motorized zoom drive, for example in operation microscopes, take as a point of departure that the mathematical curves for controlling the optical zoom elements are generated by mechanical means (e.g., two-dimensional cam + toggle contacting or three-dimensional cam, a "pot cam" as it is called) and the motor-driving of these optical elements which are controlled according to the mechanical cam is only coupled (e.g., via toothed rack and pinion) in place of the mechanical operator control (zoom button). A solution of this type is shown in Fig. 1. It is complicated and expensive because the mechanical control is retained and the motor functions merely as a driving element.

OBJECT AND SUMMARY OF THE INVENTION

The object of the invention is a simpler and more economical zoom drive for a stereo microscope.

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This object is met according to the invention ~~through the features of claim 1. Preferred further developments of the invention are contained in the dependent claims.~~

The invention starts by doing away entirely with mechanical generation of the controlling curves of the stereo microscope zoom systems (economizing on cams and a number of mechanical transmission members) and controlling the optical elements by electrical direct drives (e.g., actuators or steppers, as they are called, as linear drives with corresponding step resolution).

The reference points given by optical calculations for the mathematical controlling curve of the stereo microscope zoom system reside as programmed values in storage elements (e.g., EPROM or PC memory media). With actuation of the electric zoom operator controls (rocker switch or foot switch with forward and reverse control functions and additional "gas" function, i.e., control of the zoom drive at different speeds), the linear drives (when there are two optical elements to be driven, for example) are controlled simultaneously and cover a different number of individual steps per unit of time depending on the mathematical curve. In this way, the moving optical elements reach their reference positions to be set according to optical computation (data sheet) in discrete individual steps of varying magnitude depending on the desired zoom resolution.

Another advantage of this solution consists in that optical adjustment can be carried out via the linear drives, i.e., the predetermined mathematical

reference curve residing in memory can be changed in individual-step operation during adjustment of the optical system.

For this purpose, it is necessary to move through the zoom range and to check whether or not there is still a possible focusing deviation within the depth of focus range. This can be carried out by subjective image assessment or by objective measurement, for example, via a connected CCD camera in the imaging beam path by contrast measurement using a test object.

In case of a focusing deviation, the adjusting values of the drive motors are changed (automatically or as a manually adjusted correction) in such a way that it is eliminated and the new setting value of the drive or drives is stored (correction of apparatus error).

A readjustment of this type is possible only to a limited extent, if at all, in conventional cam drives as shown in Fig. 1.

The mathematical reference curve resides in an external computer (PC); the correction is then carried out via the external computer which is used for the working-side system programming. After programming (correction of the optical apparatus error) is carried out proceeding from the external PC, the programming of an EPROM (memory circuit) with the corrected program (corrected function value - value pair) is carried out. This EPROM is then inserted into the stereo microscope.

The invention will be explained more fully in the following with reference to schematic drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Fig. 1 shows a zoom system according to the prior art;

Fig. 2 shows a zoom system according to the invention;

Fig. 3 shows another construction with coupled lens pairs;

Fig. 4 shows a motor-driven stereo microscope; and

Fig. 5 shows the interaction between controlling and driving.

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DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 is a schematic view of a zoom drive for a Greenough type stereo microscope. Lens pairs L1, L2, L3 for the two observation beam paths are arranged on guides F1, F2. In the present case, lens group L3 is stationary and L1 and L2 are displaceable. A toggle K which is articulated at a cam KS via a roller is fastened to the drivers MN at the lens pairs L1, L2. The cam KS is connected with a toothed rack Z which is adjusted via a drive pinion R and a drive motor M, i.e., the coupled cam is driven linearly via a drive pinion R and a drive motor M, i.e., by the rotational movement of the motor and by the rack and pinion combination. The movement of the toggle K and accordingly the adjusting movement of the lens pairs L1, L2 (nonlinear mathematical function) is controlled by the shape of the cam KS.

A first construction according to the invention is shown schematically in Fig. 2. In this case, drive spindles AS1, AS2 are connected with the drivers MN of the lens pairs L1, L2; the drive spindles AS1, AS2 are controlled individually by linear driving motors LA1, LA2 which are arranged in bearings in a stationary manner and are located in the stereo microscope zoom system. The linear drives LA1, LA2 are connected with a control unit AE which is connected in turn with an input unit EE.

Another very advantageous solution for a stereo microscope motorized zoom with direct drive which is shown in Fig. 3 is given in stereo microscopes with optical compensation (Greenough type or telescope type stereo microscopes). Also, only one individual linear drive is necessary for motorization because, in this known construction with optical compensation (example taken from CZ Stemi 1000 program), two movable lens groups are rigidly connected with one another via a common drive spindle and are manually driven linearly - i.e., without cam control - via the zoom drive (rack and pinion, zoom button). In the illustrated embodiment example (see Fig. 3), the lens groups L1 and L3 which are to be moved in common are coupled with one another directly via a continuous drive spindle AS3 (play compensation, e.g., via tension spring) and are moved by the stationary linear drive LA3 ("tire jack principle").

Further, in this case, the zoom system is formed of stationary lens groups L2, L4, wherein L2 is arranged between L1 and L3. In contrast to stereo microscopes with motorized zoom and mechanical compensation, the system

adjustment cannot be carried out in this case by the linear drive in this case (mechanical-optical adjustment carried out) because it is not possible to adjust any relative movements between the separately adjustable lens groups (rigid coupling of movable lens groups).

Fig. 4 shows a schematic total view of a stereo microscope with the zoom drive according to the invention and further motor-controlled functions. It comprises a stand S at which a microscope support MT is arranged so as to be vertically adjustable by means of a focus driving motor F.

The microscope support MT is fastened to the stereo microscope MI. As is indicated schematically, a motor-operated zoom system ZS which is controlled in accordance with the invention and is shown by way of example in Figs. 2 and 3 is located in the housing of the microscope MI.

The zoom drive according to the invention can be controlled, for example, via an electric power supply AL1 which is fed through the pillar and inserted into the microscope MI. Another supply line AL2 connects the motorized focus drive F with the stand S. Rocker switches WS1, WS2 for zoom and focus and also a brightness regulator HR and lamp changeover switch LS can be provided in the stand base SFS on which the object plane OE (insert plate) is located.

The power supply SV for the stereo microscopes with motorized zoom can be carried out externally as is shown, e.g., with a wide-range plug-in power supply (manufactured by FRIWO, 90 V ... 240 V / 12 V / 10 W or 30 W plug-in power supply); for mobile use of the stereo microscope, battery or accumulator operation may possibly be advantageous (use of existing international-standard [rechargeable] accumulators, e.g., camcorder or electric screwdriver accumulators).

Since it is not possible to display the zoom factor mechanically in the case of a motorized zoom, the display could advantageously be carried out by means of an LED or LCD display A (using standardized multi-digit single-dot components) at the microscope support MT (good visibility with minimal head movement, e.g., when arranged between the ocular supports). The linear magnification to be displayed can be read off from the value pairs $z = z(\beta)$ in the EPROM and, when using a four-digit display, can be displayed with a resolution of $\Delta\beta = 0.1x$ for example (display range, e.g., for DV4: $\Uparrow$0.8x ... $\Downarrow$ 3.2x in steps of 0.1x).

After the stereo microscope is switched on, the control electronics and linear drives run through an initialization phase in order to find the zero points of the linear drives and, for example, to move the zoom drive to the lowest linear magnification (low-power magnification). Other operating states of the system (e.g., initialization, additional focusing information) could also possibly be displayed via the display.

In an alternative display of linear magnification and other operating states in the intermediate image of the ocular (not shown) (integration of miniature LEDs in the intermediate image of the ocular with minimal limitation of the viewing field, external powering of ocular display via cable proceeding from stereo microscope base body, similar to CZ-manufactured oculars with illuminated cross-lines grid with static image or similar to LED illumination principle for data exposure in photographic cameras), the observer need not interrupt viewing through the ocular (considerable advantage in the case of manipulation tasks) for monitoring operating parameters (e.g., linear magnification). Another technical solution is the display of data in the intermediate imaging plane of the ocular via a transparent, plane-parallel LCD matrix over the entire viewing field.

The combination of motorized zoom and motorized focus (principle of the operation microscope) represents a considerable advantage with regard to manipulation tasks in stereo microscopy. The use of the motorized focus F in the focus drive for the stereo microscope support does not have to do with the use of an autofocus system (sometimes large depth of field of the stereoscopic object by a multiple of the depth of focus), but rather the motorization and remote controllability (e.g., also including via foot switches FS1, FS2 for zoom and focus) of these operating functions in manipulation tasks.

In terms of technique, there is a wide variety of known solutions for manually controllable motorized focusing systems for microscopy in general and also for stereo microscopes in particular (especially operation microscopes). The combination of the stereo microscope motorized zoom according to the invention and the stereo microscope motorized focus known from the prior art (motorized focus systems integrated in the basic device or mounted piggyback on the stereo microscope support) which is very useful for the user can be mentioned as a subclaim.

The fully motorized stereo microscope corresponding to Fig. 4 is a combination of the above-mentioned motorized operating functions of motorized zoom, motorized focus and motorized auxiliary lens system (variable adjustment of front focal distance).

Fig. 5 shows a schematic view of the interaction between the drives for the zoom system and the focus, including its controls and the power supply and associated operating controls.

Operating controls and control unit can also be operated via a PC and a user surface on the screen of the PC.

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